STUDIES IN VICTORIAN VEGETATION, II

A FLORISTIC SURVEY OF THE VEGETATION ASSOCIATED WITH *Nothofagus cunninghamii* (HOOK.) OERST. IN VICTORIA AND TASMANIA

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ABSTRACT: A floristic analysis of the vegetation associated with *Nothofagus cunninghamii* shows that considerably greater vegetation variation exists than has been revealed by previous structural and dominance studies. Two major Associations have been identified, one restricted to Tasmania, the other occurring in both Victoria and Tasmania, and consisting of numerous variants. The variants are described and discussed with respect to other vegetation studies and the species which are characteristic of these groups have been used in the production of a floristic 'key' to the vegetation. This should be useful in the understanding of the relationships of particular stands to the vegetation as a whole. The major gradient in the vegetation is correlated strongly with altitude, a finding which agrees with previous studies.

INTRODUCTION

Nothofagus cunninghamii is distributed over much of Tasmania and occurs sporadically in the southern central region of Victoria (Howard & Ashton 1973). It is found in vegetation variously described as 'temperate rainforest' (e.g. Beadle & Costin 1952, Gilbert 1958, Wood & Williams 1960); 'microphyll moss forest' and 'microphyll moss thicket' (Webb 1959); and, more recently 'nanophyll moss forest' and 'nanophyll moss thicket' (Webb 1968). The Victorian forests were recently described by Howard and Ashton (1973) as 'Tall Closed Forest', 'Closed Forest', and 'Low Closed Forest' based on a scheme proposed by Specht (1970). Their study included an analysis of floristic data from seventeen stands in Victoria but the major emphasis was on the forest structure.

It has been claimed that vegetation classifications based on physiognomy or 'dominant species' are less precise than those based on floristics (Goodall 1953, Moore et al. 1970). Obviously it cannot be assumed *a priori* that classifications based on physiognomy or 'dominant species' are less precise than those based on floristics (Goodall 1953, Moore et al. 1970). Obviously it cannot be assumed *a priori* that classifications based on physiognomy will also represent the main floristic differences (Moore 1962, Noy-Meir 1972), so this study was undertaken to examine the floristic variation in these forests and to compare the results with those of previous studies.

METHODS

Data Collection: Some 100 vegetation samples (10m x 10m) were taken from sites containing *N. cunninghamii* over its known altitudinal range in Victoria, and over as much of its range as practical in Tasmania during the time available for sampling. Samples were not taken in sites of obvious disturbance, or in clear ecotones between distinct plant communities. Presence, rather than dominance, of *N. cunninghamii* was used as the sampling criterion. Victorian samples were numbered from 1 to 55 and the Tasmanian samples from 101 to 145.

A total of 178 vascular plant species were recorded, ferns in the family Hymenophyllaceae and non-vascular plants being excluded. Their small size should reflect only microenvironmental factors and so should contribute little useful information to a primary survey. Each species record was accompanied by a cover/abundance symbol (Braun-Blanquet 1964) to provide additional descriptive information of the stand and these data were transferred to computer cards for analysis. Species occurring in less than 5% of the

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FIG. 1—Location of sample sites in Victoria.

FIG. 2—Location of sample sites in the Central Highlands region of Victoria.

FIG. 3—Location of sample sites in the Otway Ranges, Victoria.

samples were excluded from subsequent analysis.

Data analysis: After being checked for accuracy, the data were arranged in a two-way table by the Fortran IV Program ZUMONT/PRINT, written for the Monash University Burroughs B6700 computer. Species and samples form the rows and columns respectively of this table (Fig. 5) and the analysis of the data involved the repeated visual sorting of the species and samples until the species records were highly concentrated at the top of the table (c.f. Bridgewater 1971). The computer program was used to print out new tables at various stages in this process until it was decided that further sorting was unnecessary.

The Zurich-Montpelier (Z-M) type of analysis, though simple in concept, is frequently difficult and tedious in practice. The process can, however, be accelerated by the use of numerical methods to give preliminary sample and/or species groups (e.g. Ceska & Roemer 1971, Lieth & Moore 1971).

This method has been criticised because it is 'subjective', in that the order of samples and species is determined by the investigator (e.g. Dale & Anderson 1972). Moore et al. (1970), on the other hand, state that the order of species and samples is determined by the data, and that the sorting process is, in reality, a polythetic divisive method based on visual ranking of correlated species and sites rather than operating via a particular statistic. The sorting process described above attempts to ensure that samples which are most similar to each other lie side by side in the table.

A comparison of the results of this process (Fig. 5) with the results of an association analysis (Williams & Lambert 1959) and a cluster analysis (Carlson 1972) performed on the same data showed no significant differences between them (Table 1). (For additional information see Busby 1973, pp. 70-71, also Appendix VI).

The classifications were compared, in pairs, using a method devised by Kullback et al. (1962). Information statistic values were calculated for each comparison and these values (multiplied by two) were assessed for significance against the theoretical probability distribution x^2 at P=0.0005 with the relevant degrees of freedom under the null hypothesis that, in each com-

TABLE 1

PERCENTAGE INCREASE OF INFORMATION STATISTIC VALUE (X 2) OVER x^2 (P=0.0005).

	Analysis		
	Z-M	Association (x^2, P=0.05)	Cluster
Z-M analysis	—	157.9	110.7
Association analysis		—	161.3
Cluster analysis			—

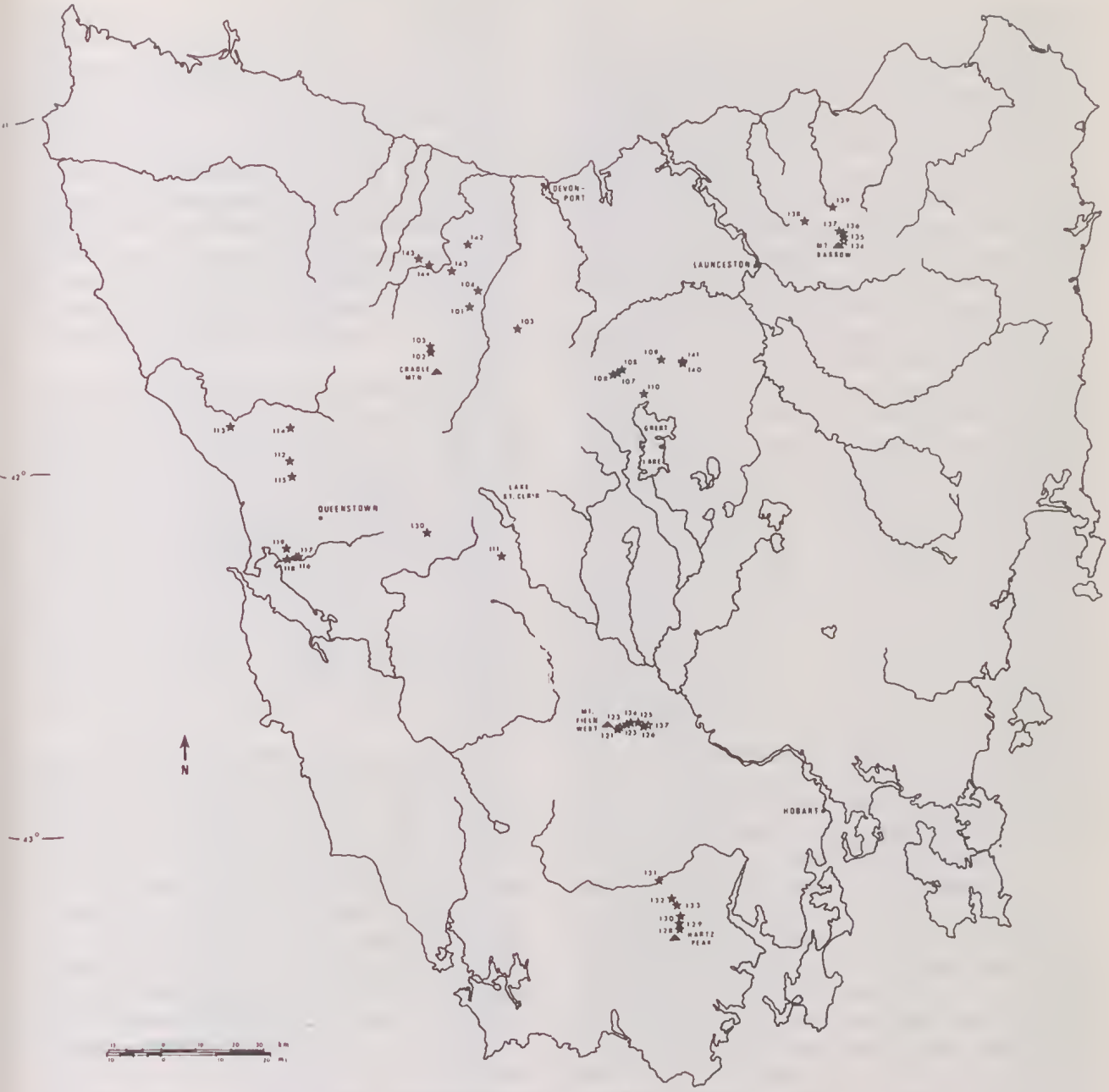

FIG. 4—Location of sample sites in Tasmania.

parison, the two classifications were unrelated. The values shown in Table 1 are the percentage increase of the information statistic value (x 2) over the value of x^2 at P=0.0005 and indicate that, in each comparison, the probability that the classifications are unrelated is less than 0.0005.

SPECIES GROUPS ASSOCIATED WITH *Nothofagus cunninghamii*

An examination of the sorted data in Fig. 5 show them to be concentrated into 'blocks' of species records. This feature has been noted in many such tables, recent examples including Webb et al. (1970) and Walker (1972). Most of these blocks (or 'noda' *sensu* Poore 1955) show internal variation and grade into each other. Despite this, twelve distinct sample groups and four fragmentary groups can be detected.

It is apparent that two quite distinct plant communities are present. These two communities are called, for the purposes of the following discussion, Association A and B. (Association A includes groups A.1 through A.4 in Fig. 5). Although there is no need for noda to be hierarchically related (Noy-Meir 1972), groups A.1 to A.4 can be considered to be Sub-

Associations of Association A, and two of these groups, A.2 and A.3, contain sub-groups or Variants.

The term Association is taken in this context to mean a plant community of uncertain status in the vegetation as a whole but which is considerably different from other communities under consideration. Associations defined in this way are based entirely on floristics and may or may not correspond to 'Associations' based on structural features of the vegetation. This confusion is unfortunate but it illustrates the necessity of deriving a standard system for establishing the status and nomenclature of different types of vegetation.

Association A is characterized by the presence of *Blechnum procerum, Dicksonia antarctica* and *Polystichum proliferum.* Association B is characterized by the presence of *Bauera rubioides, Coprosma nitida, Cyathodes parvifolia, Eucalyptus coccifera, Orites diversifolia, Telopea truncata,* and *Trochocarpa gunnii.*

Association B is completely restricted to Tasmania and most of its characteristic species are endemic to that State. Samples of this vegetation type were collected on Mt. Barrow, Mt. Field Plateau, and Hartz Mountains. (Fig. 4). This Association corresponds to the 'nanophyll moss thicket' of Webb (1968) and appears to consist mainly of the 'Small Eucalyptus Scrub Association' with elements of the 'Low Mountain Forest Association' of Gibbs (1920). It also appears to correspond to the '*Eucalyptus-Nothofagus*' forest recorded by Sutton (1928) on Cradle Mountain and the '*Eucalyptus coccifera* consociation' and '*E. coccifera-urnigera* association' described by Martin (1940) on Mt. Wellington. From descriptions by these workers it is evident that there is greater variation in this vegetation than has been demonstrated in this survey. This is due to the fact that this Association is restricted to exposed mountain tops, particularly in south-west Tasmania, and most of these locations were inaccessible to this primary survey. This vegetation is quite different from the other vegetation containing *Nothofagus cunninghamii* and further work is necessary to describe it fully. The relative paucity of species in sample 134 from Mt. Barrow (see Fig. 4) perhaps indicates that this represents an outlying occurrence of a type which is concentrated in the south-west of the State.

Association A consists of four 'Sub-Associations' and is found in both Victoria and Tasmania. The numbering system (outlined above) enables one to scan the top line of the sample numbers in Fig. 5 (the sample numbers are printed vertically) and readily distinguish the Tasmanian samples (1) from the Victorian samples (0). This group appears to correspond with the 'microphyll moss forest' of Webb (1968).

Sub-Association A.1 is characterized by *Acacia dealbata, Cyathea australis, Tetrarrhena juncea,* and *Tieghemopanax sambucifolius.* Other conspicuous species include *Acacia melanoxylon, Blechnum nudum, Clematis aristata, Todea barbara,* and *Viola hederacea. Polystichum proliferum,* one of the differential species of Association A, is not common in this group. This vegetation may be a part of the 'Tall Closed Forest' of Howard and Ashton (1973) but was apparently not surveyed in their study. It appears to occur mainly at the limits of *Nothofagus cunninghamii* distribution and perhaps represents a region of overlap between forest dominated by this species and that dominated by eucalypts. *Eucalyptus regnans,* for example, is more conspicuous in this than in any other group.

Sub-Association A.2 is found in both Victoria and Tasmania and is characterized by the presence of *Atherosperma moschatum* and *Grammitis billardieri.* This group appears to correspond to 'Temperate Rain Forest' as defined by Gilbert (1958), viz. an association of *Nothofagus cunninghamii* and *Atherosperma moschatum.* The group also appears to correspond to the 'Tall Closed Forest' and 'Closed Forest' of Howard and Ashton (1973) and it is in this vegetation that *Nothofagus cunninghamii* reaches its greatest physiognomic development. This can be seen in the consistently high cover/abundance values in Fig. 5. Eucalypts are less conspicuous in this than any other group.

Six variants can be distinguished within this group: A.2.1 through A.2.6. Variant A.2.1 is characterized by the presence of *Clematis aristata, Hedycarya angustifolia, Microsorium diversifolium, Pittosporum bicolor,* and *Rumohra adiantiformis.* Variant A.2.2 is characterised by the presence of the above species with the addition of *Asplenium bulbiferum, Athyrium australe,* and *Blechnum aggregatum.* Variant A.2.3 is characterized by *Asplenium bulbiferum, Blechnum aggregatum,* and *Microsorium diversifolium.* The last of these species is the only differential species for A.2.4. Variant A.2.5 is a quite different group, consisting almost entirely of species endemic to Tasmania, viz. *Anodopetalum biglandulosum, Anopterus glandulosus, Eucryphia lucida, Gahnia grandis,* and *Phyllocladus asplenifolius. Microsorium diversifolium* is absent and two of the differential species for the Association, i.e. *Dicksonia antarctica* and *Polystichum proliferum,* are not conspicuous. Variant A.2.6 contains no differential species in addition to *Atherosperma moschatum* and *Grammitis billardieri* which are are differential species for the Sub-Association.

Species lists in various published works sometimes enable the identification of the plant groups present in these forests. Variants A.2.1 to A.2.4 (the exact group depending on certain species which may not have been recorded) can be identified in the work of Gibbs

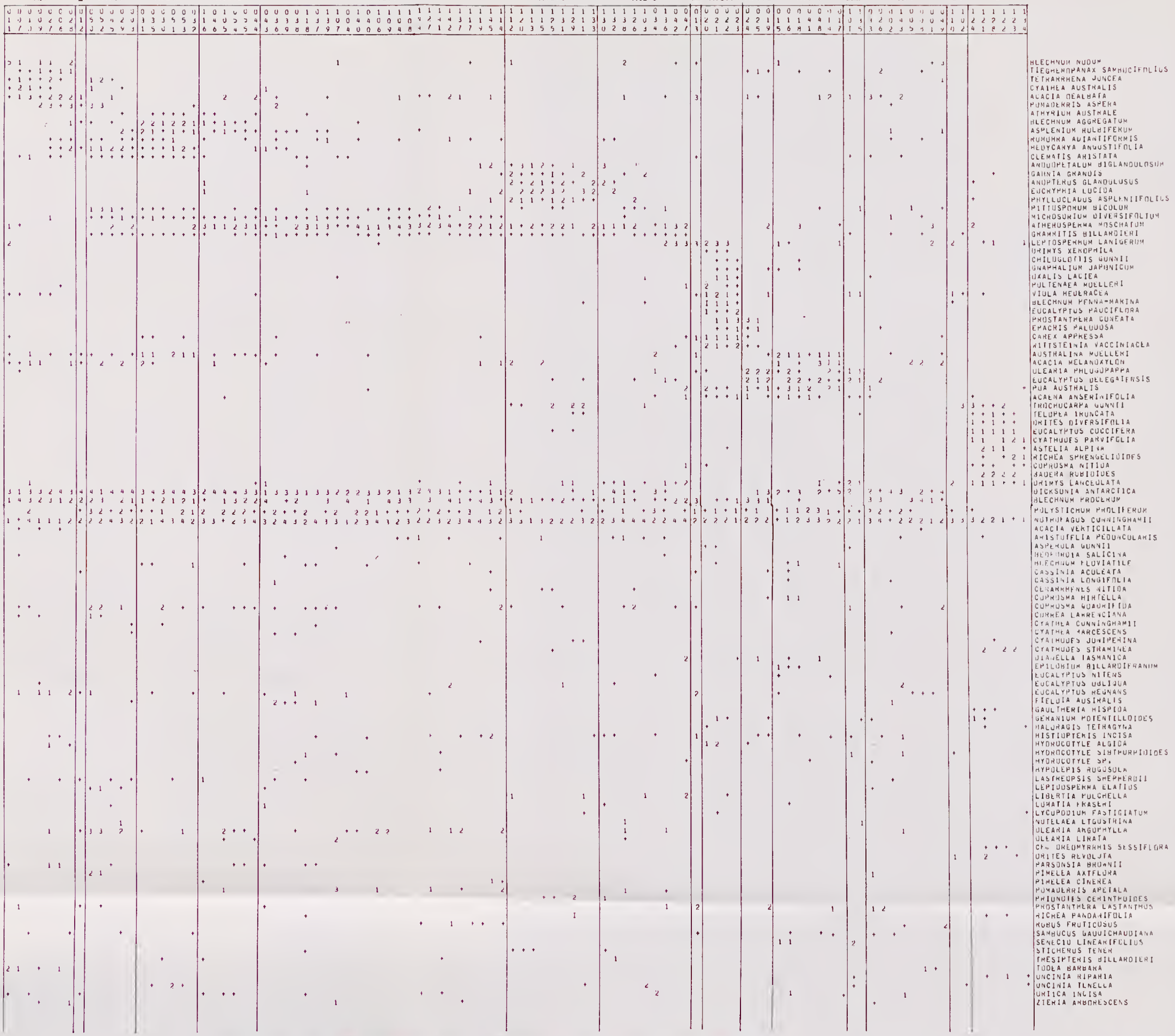

FIG. 5.—Two-way table of vegetation data from all Victorian and Tasmanian sites. The table was produced by the computer program ZUMONT/PRINT. Sample numbers should be read downwards.

(1920), Morris (1929), Perie et al. (1929), Martin (1940), Howard and Hope (1969) and Howard and Ashton (1973). Variant A.2.5, being fairly distinct, can be clearly detected in work published by Davis (1940) and Gilbert (1958), and perhaps also Gibbs (1920).

The absence of *Atherosperma moschatum* from eight of the samples in A.2.1 and A.2.2 is an interesting feature of this Sub-Association. The samples concerned are all from the Otway Ranges (Fig. 3) where this species has never been recorded. The table strongly suggests that this species is not absent for ecological reasons, although Howard and Ashton (1973) suggest that it might have been eliminated by fire and could not re-establish itself because of the isolation of this region from other seed sources. An alternative suggestion is that it was never present in the Otways due to the lack of suitable habitats between this region and areas further east where it may have originated (N. A. Wakefield, pers. comm).

Sub-Association A.3 appears to be confined to Victoria and is mainly a sub-alpine plant community. In this community *Nothofagus cunninghamii* is generally found as a large shrub under a canopy of eucalypts and the vegetation type appears to correspond to the 'Low Closed Forest' of Howard and Ashton (1973). The differential species are *Acaena anserinifolia* and *Poa australis* and three variants can be distinguished, A.3.1 through A.3.3.

Variant A.3.1 consists of samples taken on Mt. Baw Baw, Victoria and this vegetation appears to be confined to that locality. A study by Morris (1929) indicated that similar vegetation may occur on Echo Flat, Lake Mountain (Fig. 2), but a superficial survey failed to locate it. This vegetation is characterized by *Blechnum penna-marina, Carex appressa, Eucalyptus pauciflora, Viola hederacea,* and *Wittsteinia vaccinacea*. An additional eight species are conspicuous in this vegetation and these can be seen in Fig. 5. An interesting feature is the absence of *Dicksonia antarctica*. The group, however, contains only four samples so further work is necessary to clearly define it. However, it is apparent that it is quite distinct from the others and further sampling would be expected to enhance this difference.

Variant A.3.2 is also incompletely defined, consisting of only three samples. Further work is needed in this vegetation also to properly define it. Possible differential species are *Eucalyptus delegatensis, Olearia phlogopappa,* and *Tieghemopanax sambucifolius* and perhaps some of the following: *Acacia dealbata, Epacris paludosa, Histioperis incisa, Prostanthera cuneata* and *Wittsteinia vaccinacea*.

It should be noted that *Tieghemopanax sambucifolius* is also a differential species of Sub-Association A.1. This suggests that this species may, in fact, be composed of more than one 'ecotype'. Willis (1972) notes for this species that 'invariably in the subalps and often also in the lowlands, leaflets are linear and obtuse . . . In moist lowland forests the leaflets bay be lanceolate to broadly ovate and acute or obtuse . . . Autecological work in this species is needed to clarify the situation.'

An examination of Fig. 5 will show other species which have distributional patterns which could prompt similar questions, e.g. *Acacia melanoxylon, Australina muelleri,* and *Viola hederacea*.

Variant A.3.2, in fact, appears to be intermediate between A.3.1 and A.3.3. Variant A.3.3 is characterised by *Acacia melanoxylon, Australina muelleri, Eucalyptus delegatensis,* and *Olearia phlogopappa*. An interesting feature of this group is the virtual absence of *Blechnum procerum,* a species which is characteristic of every other group in Association A.

Sub-Association A.4 is the 'typicum' for Association A in that it contains no characteristic species in addition to the ones which characterize the Association.

The main groups in the table are all linked by intermediate samples. Fragments I to III occur between the Sub-Associations in Association A and Fragment IV is intermediate between Associations A and B. Further work will be necessary to establish the status of these fragments. The *'Athrotaxis-Nothofagus'* forest described by Sutton (1928), for example, appears to be intermediate between these Associations, and the status of Fragment IV may be clarified by further work in this forest type.

FLORISTIC KEY TO THE VEGETATION

Since the vegetation in which *Nothofagus cunninghamii* occurs can be classified into a number of species groups, it was possible to devise a floristic 'key' to this forest (Appendix 1). The main uses of this key would be to allow new vegetation samples to be rapidly alloeated to the existing classification, and to enable other workers to identify the vegetation type under study so that they can establish the status of their particular stand of vegetation relative to the forest as a whole. This information is essential in determining the limits of extrapolation for detailed work in any part of the forest (c.f. Austin 1972). In other words, ecological observations must be specified in terms of the community in which they are made (Poore 1962) and results of investigations into one type are not necessarily applicable to another (Moore 1962).

DISCUSSION

The main vegetation groups, as indicated above, appear to correspond closely with previously published

structural classifications. It is also apparent, however, that this floristic analysis has detected the presence of vegetation categories which have not been previously described. Further work, of course, is necessary to clarify the status of some of these groups and to determine reasons for the differences between them. Because of the repeated disturbance of this forest by fire and man, many of these groups may well represent successional stages, but this remains to be confirmed.

. Re-analysis of the floristic data presented by Howard and Ashton (1973), using the floristic key presented in Appendix 1, showed that their 'Tall Closed Forest' corresponds to groups A.2.1 (three of their stands), A.2.2 (two stands), A.2.3. (two stands) and A.2.6 (one stand). The 'Closed Forest' corresponds to groups A.2.2. (one stand), A.2.6 (four stands) and A.4 (one stand). The two structural types appear to reflect floristic differences to a certain extent but the distinction between them requires further clarification.

The strong altitudinal zonation recorded by Howard and Ashton (1973) is also reflected in this analysis. The average altitude in each of the 12 sample groups was calculated and is shown in Table 2. In sample groups which contained both Victorian and Tasmanian samples (A.2.3, A.2.4, and A.4), the averages for the Victorian samples (V), and Tasmanian samples (T), were calculated separately. It can be noted that, within the sample group, the Victorian samples consistently have a higher average altitude than the Tasmanian samples, the average difference being 370 metres. This difference in altitude is attributed to environmental differences which are correlated with latitude differences, Tasmanian forests being, on average, 4° further south. An interesting point about two of the samples in Association B (128 and 134) which are separated by 2° of latitude, is that the southern sample (128) is 410 m lower in altitude than the northern one (134). It is suggested that Sub-Association A.1 (average altitude 330 m), which is recorded from Victoria only, will not be found in Tasmania because of this factor, except possibly in some restricted areas. It should also be noted that no Tasmanian samples were classified into groups A.2.1 and A.2.2.

If the altitude of the Tasmanian samples is 'corrected' for this latitude difference by the addition of 370 m to the altitude of each sample, then these 'corrected' altitudes show a sequence of increasing values from one group to the next (Table 2).

There is, however, considerable variation in altitude within each group so that the averages are rather poor estimates of the true means. This implies, of course, that the 'average' altitude difference between Victoria and Tasmania is only an approximation and further studies will be necessary. The variation, after all, is only to be expected since other factors such as exposure are almost certainly involved.

TABLE 2

RELATIONSHIPS BETWEEN SAMPLE GROUPS AND ALTITUDE (M). See text for description of 'corrected' altitude.

Sample Group	Average Altitude	Altitude Difference	'Corrected' Altitude
A.1	330	—	330
A.2.1	440	—	440
A.2.2	420	—	420
A.2.3	580(V) 180(T)	400	570
A.2.4	630(V) 410(T)	220	730
A.2.5	390	—	760
A.2.6	1140(V) 520(T)	620	970
A.3.3	1060	—	1060
A.3.2	1070	—	1070
A.3.1	1320	—	1320
A.4	660(V) 430(T)	230	650
B	1350	—	1350

It can be noted that Sub-Association A.4 is an exception to the gradient. This group, as discussed above, is the 'typicum' for Association A and the lack of character species in addition to the ones defining the Association makes its status in the vegetation a little obscure. Its position in the altitude gradient appears to indicate that it has been misplaced in Fig. 5 but perhaps its species composition is controlled by factors which are not correlated with the main gradient.

Another point is that Variants A.3.1 and A.3.3 have been reversed in Table 2. This was done on the basis of their average altitudes and re-examination of Fig. 5 which indicates that the floristic picture would not be disrupted if they were also to be reversed in the two-way table. Variant A.3.1 was located next to A.2.6 in Fig. 5 because they both contained *Leptospermum lanigerum*. This name was used *sensu lato* as in Ewart (1931) on the basis of an identification by the National Herbarium early in the sampling program. This name includes *L. glabrescens* N. A. Wakefield and *L. grandifolium* Sm. (Willis 1972, p.449) and both species were probably encountered in this survey. The altitude differences between A.3.1 and A.2.6 suggests that the former may contain *L. grandifolium* and the latter *L. glabrescens*. If this is so then the analysis has been useful in pointing out taxonomic differences which were not recognised in the field (see also the case of *Tieghemopanax sambucifolius* discussed above).

An interesting feature of the analysis is the quite